

HIGH FREQUENCY AMPLIFICATION CIRCUIT

TECHNICAL FIELD

The present invention relates generally to the field of wireless communication
5 and, in particular, to a high frequency amplification circuit.

BACKGROUND

Wireless telecommunications systems transmit signals between users using radio frequency (RF) signals. A typical wireless system includes a plurality of base stations
10 that are connected to the public switched telephone network (PSTN) via a mobile switching center (MSC). Each base station includes a number of radio transceivers that are typically associated with a transmission tower. Each base station is located so as to cover a geographic region known colloquially as a "cell." Each base station communicates with wireless terminals, e.g. cellular telephones, pagers, and other
15 wireless units, located in its geographic region or cell.

A base station includes a number of modules that process RF signals for communication with wireless terminals, e.g., cellular telephones, pagers. The modules of a typical base station include, by way of example, mixers, amplifiers, filters, transmission lines, antennas and other appropriate circuits. Each module of the base
20 station is designed to allow the base station to communicate with wireless terminals in one of a number of possible frequency bands based on the service supported by the base station.

A variety of wireless services are offered throughout the world. For each service, a specific band or bands of the frequency spectrum is licensed for providing the
25 service. For example, in the United States, cellular telephone service is typically available in the 824 - 849 Megahertz (MHz) and 869 - 894 MHz frequency bands and personal communication services (PCS) are offered in the 1850 - 1990 MHz frequency range. Conventionally, each service that is offered uses its own set of base stations. This is due in part to the fact that signals of the various services have different ranges

due to differences in the frequencies of the signals being transmitted. Unfortunately, this does not allow a service provider to adequately leverage off existing infrastructure used for a first service when introducing a second service in a different frequency band in the same service area.

- 5 For the reasons stated above, and for other reasons stated below which will become apparent to those skilled in the art upon reading and understanding the present specification, there is a need in the art for improvements in implementing services in a single geographic area that use different portions of the frequency spectrum.

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SUMMARY

- The above mentioned problems with wireless networks and other problems are addressed by embodiments of the present invention and will be understood by reading and studying the following specification. Embodiments of the present invention provide an amplification circuit that selectively amplifies signals in a frequency band associated
15 with a first service and passes, without amplification, signals in a second frequency band associated with a second service such that base stations can support both first and second services over a substantially co-extensive geographic region.

More particularly, in one embodiment an amplification circuit for a wireless base station is provided. The amplification circuit includes a first port adapted to
20 communicate signals to and from an antenna and a second port adapted to communicate signals to and from a base station. The amplification circuit further includes a first path and a second path with each path coupled between the first and second ports. The first path includes at least one bandpass filter and an amplifier that pass and amplify upstream signals in a first frequency band. The second path includes a filter that stops
25 upstream signals in the first frequency band and passes upstream signals in at least a second frequency band and downstream signals in at least third and fourth frequency bands.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a block diagram of an embodiment of an arrangement for an antenna of a base station with an amplification circuit constructed according to the teachings of the present invention.

Figure 2 is a block diagram of an embodiment of a base station including an
5 amplification circuit according to the teachings of the present invention.

Figure 3 is a block diagram of a wireless system including base stations with high frequency amplification circuits according to the teachings of the present invention.

Figure 4 is a block diagram of another embodiment of a base station including a plurality of cascaded amplification circuits according to the teachings of the present
10 invention.

DETAILED DESCRIPTION

In the following detailed description, reference is made to the accompanying drawings that form a part hereof, and in which is shown by way of illustration specific
15 illustrative embodiments in which the invention may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention, and it is to be understood that other embodiments may be utilized and that logical, mechanical and electrical changes may be made without departing from the spirit and scope of the present invention. The following detailed description is,
20 therefore, not to be taken in a limiting sense.

Figure 1 is a block diagram of an embodiment of an arrangement for an antenna for a base station with an amplification circuit, indicated generally at 100, and constructed according to the teachings of the present invention. Amplification circuit 100 is adapted to be used as a tower top amplifier in a wireless base station in a system
25 that supports services in at least two different frequency bands, e.g., any two of Advanced Mobile Phone Service (AMPS), Nordic Mobile Telephone (NMT) service, Total Access Communication System (TACS), digital cellular using Time Division Multiple Access (TDMA), e.g., Global System for Mobile Communications (GSM) or Code Division Multiple Access (CDMA), digital Personal Communications Service

(PCS), or any other appropriate wireless communication service whether existing or later developed. For purposes of this specification, the term "upstream" means communications from wireless terminals to a base station and the term "downstream" means communications from base stations to wireless terminals.

- 5 Amplification circuit 100 amplifies only a portion of the upstream frequency spectrum received at the base station, e.g., the upstream frequency band of one of the supported services. Through this selective amplification, amplification circuit 100 improves the signal-to-noise ratio at the receiver portion of the base station transceiver of the service using a higher frequency band so that the base station can support the
10 service over a larger geographic area. When sufficient amplification is provided, each base station provides coverage for both services over a co-extensive geographic region. Thus, amplification circuit 100 allows a service provider to use the same base stations for supporting two or more different services that use different frequency bands even though transmissions from wireless terminals at different frequencies for the services
15 may have different strengths when received at the base stations.

Amplification circuit 100 processes signals received at antenna 102. Amplification circuit 100 includes first and second paths 104 and 106, respectively. First path 104 selectively amplifies signals in an upstream frequency band associated with a first service. In one embodiment, first path 104 selectively amplifies signals for a
20 personal communication service (PCS) operating in the frequency range of approximately 1850 to 1990 MHz. In other embodiments, first path 104 amplifies signals in a frequency band associated with other selected services whether currently existing or later created. Second path 106 selectively passes signals in an upstream frequency band associated with at least one additional service. Second path 106 also
25 passes downstream signals for the first and the at least one additional service. In one embodiment, this additional service comprises a conventional cellular service such as analog AMPS in a frequency range between 800 and 900 MHz.

First path 104 is coupled to receive upstream signals from antenna 102. First path 104 includes first bandpass filter 108, amplifier 110, and second bandpass filter

112. First and second bandpass filters 108 and 112 each include a pass band that is
designed to pass signals in a portion of the frequency spectrum associated with the first
service. First bandpass filter 108, amplifier 110, and second bandpass filter 112 are
coupled in series between a first port associated with antenna 102 (the “antenna port”)
5 and a second port of amplification circuit 100 that communicates with a base station
transceiver (the “base station port”).

Second path 106 includes band stop filter 114. The band stop filter 114 is
designed to prevent the passage of upstream signals in a frequency band associated with
the first service. Therefore, band stop filter 114 is also designed to pass signals in the
10 upstream frequency band if the at least one additional service and to pass signals in the
downstream frequency bands of the first and the at least one additional service.

In operation, amplification circuit 100 receives and selectively amplifies
upstream signals at a base station in a wireless network and receives and passes
downstream signals. In one embodiment, the upstream signals received by
15 amplification circuit 100 comprise signals from wireless terminals associated with first
and second services. The upstream signals from the first, higher frequency, service are
passed and amplified in first path 104 while signals for the second, lower frequency,
service are passed by path 106. Further, downstream signals generated at the base
station for both services are passed by second path 106.

20 In first path 104, first bandpass filter 108 passes upstream signals in the
upstream frequency band associated with the first service. The signals are amplified in
amplifier 110. Further, the amplified signals are passed to and filtered by second
bandpass filter 112.

In second path 106, band stop filter 114 passes signals in both upstream and
25 downstream directions in frequencies outside of the upstream frequency band associated
with the first service. Therefore, band stop filter 114 passes, without amplification,
signals in the upstream frequency band associated with the at least one additional
service and the downstream frequency bands of the first and the at least one additional
service.

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- It is noted that the term "band stop filter" as used in this specification means a filter that selectively stops a selected frequency band for one service and allows upstream and downstream frequency bands for other services to be passed. Thus, it is not necessary that the band stop filter have a pass band down to DC. In fact, the
- 5 effective bandwidth of the band stop filter may be limited in some embodiments by DC grounding of the antenna port for protection from lightning. In most cases, it is sufficient if the band stop filter passes signals within the range from 500 to 2500 MHz with the exception of the selected upstream frequency band, e.g., 1850 - 1910 MHz.
- 10 Figure 2 is a block diagram of an embodiment of a base station, indicated generally at 200, including an amplification circuit 204 according to the teachings of the present invention. Base station 200 advantageously supports multiple services using different frequency bands over co-extensive geographic ranges through the inclusion of amplification circuit 204.
- 15 Amplification circuit 204 includes first and second paths 206 and 208. First and second paths 206 and 208 are each coupled to antenna 202. Further, first and second paths 206 and 208 are each coupled to transceiver 210 over common feeder cable 212. It is noted that feeder cable 212 is also coupled to carry downstream signals to antenna 202 from transceiver 210. Transceiver 210 provides an output for base station 200. It is understood that transceiver 210 includes any appropriate receiver and transmitter for processing signals according to selected wireless standards whether currently existing or later developed. In one embodiment, first path 206 includes an amplifier that amplifies signals in a frequency band for a first service and second path 204 passes upstream signals, without amplification, in at least a second frequency band for a second service.
- 20 Further, second path 204 passes, without amplification, downstream signals for both the first and second services. In one embodiment, amplification circuit 204 is constructed according to the teachings of amplification circuit 100 Figure 1.
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Figure 3 is a block diagram of a wireless system, indicated generally at 300, including base stations 304-1, . . . , 304-N with high frequency amplification circuits

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- according to the teachings of the present invention. Wireless system 300 includes mobile switching center 302 that connects base stations 304-1, . . . , 304-N with the public switched telephone network (PSTN) 306. Wireless system 300 advantageously supports at least two services with different frequency bands using a common set of
- 5 base stations 304-1, . . . , 304-N that each service the same geographic area for both services. Base stations 304-1, . . . , 304-N each including a high frequency amplification circuit, such as amplification circuit 100 of Figure 1. This amplification circuit selectively amplifies upstream signals in a first frequency band associated with a first service, e.g., a frequency band associated with personal communications services (PCS),
- 10 and selectively passes upstream signals in a second frequency band associated with a second service, e.g., analog cellular service, and downstream signals for both services. It is understood that wireless system 300, in other embodiments, supports any appropriate combination of services with a common set of base stations 304-1, . . . , 304-N for the services.
- 15 Figure 4 is a block diagram of another embodiment of a base station, indicated generally at 400, including a plurality of cascaded amplifiers 406-1, . . . , 406-N, according to the teachings of the present invention. In this embodiment, base station 400 supports up to (N+1) services by providing cascaded amplifiers 406-1, . . . , 406-N. Each amplifier 406-1, . . . , 406-N selectively amplifies an upstream frequency band for
- 20 a selected service, passes upstream frequency bands for the other services and passes downstream frequency bands for each of the services.

Transceiver 408 receives and transmits signals for base station 400. It is understood that transceiver 408 includes any appropriate receiver and transmitter for processing signals according to selected wireless standards whether currently existing or later developed. In one embodiment, amplifiers 406-1, . . . , 406-N are constructed according to the teachings of amplification circuit 100 Figure 1.

In one embodiment, amplifiers 406-1, . . . , 406-N are coupled to allow DC power received at amplifier 406-1 to be passed through the chain of amplifiers to amplifier 406-(N-1). DC power is supplied over feeder cable 410 from transceiver 408.

Amplifiers 406-1, . . . , 406-(N-1) are each powered by this DC power from transceiver 408 and pass the power up the chain to amplifier 406-(N-1).

- Amplifier 406-N is powered in a more conventional manner. Specifically, the antenna port of amplifier 406-N is coupled grounded for protection from lightning
- 5 strikes. Amplifier 406-N further includes a bias-T circuit that removes DC power from the connection with amplifier 406-(N-1). This feature takes advantage of the fact that bandstop filters used in amplifiers 406-1, . . . , 406-(N-1) are not inherently DC grounded and thus can pass DC power if neither of the amplifier's ports are grounded.

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Conclusion

Although specific embodiments have been illustrated and described in this specification, it will be appreciated by those of ordinary skill in the art that any arrangement that is calculated to achieve the same purpose may be substituted for the specific embodiment shown. This application is intended to cover any adaptations or
15 variations of the present invention. For example, the application is not limited to the services identified herein. Amplification circuit 100, in other embodiments, operates on signals for any two services with one service operating at a higher frequency.

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